Thermal Dissipation Sap Velocity

- Principle of Measurement
- Specifications
- System overview
- Features & Benefits
- Installation Procedures and tips
- Applications

TDP - How Does it Work

- Probe consists of two needles
  - One incorporating a (-) Reference T-Type Thermocouple
  - One incorporating a (+) T-Type Thermocouple & Heater

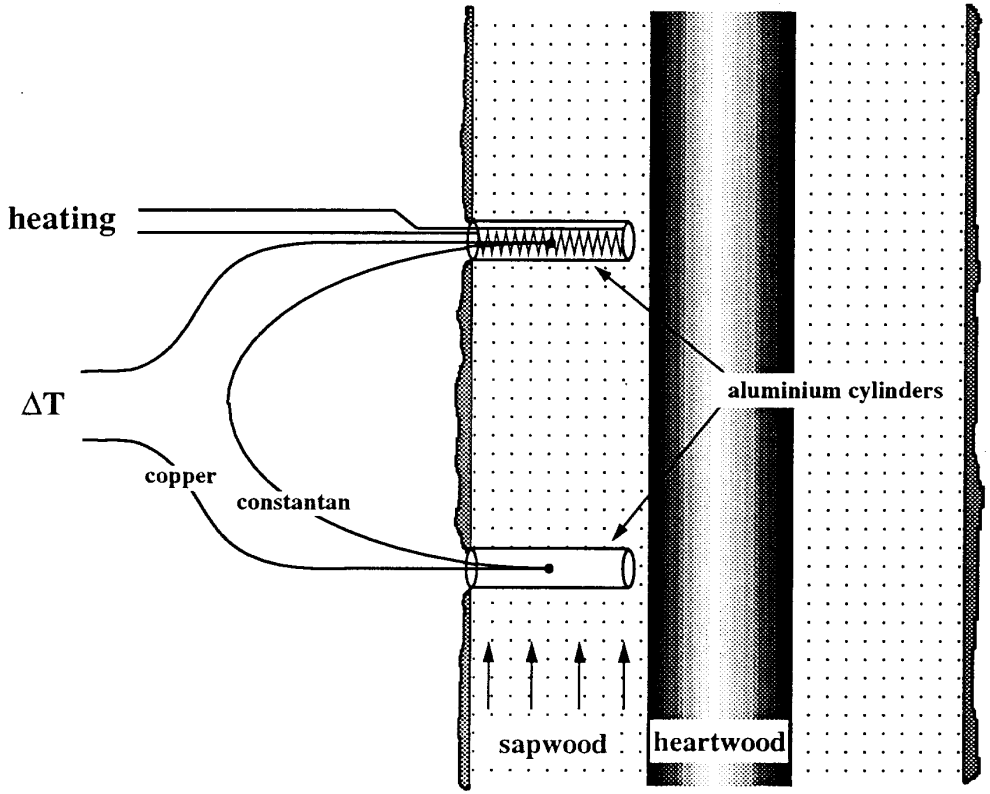
- Heated upper needle temperature is compared to lower ambient temperature needle (dT)
  - Maximum dT occurs when the needle is hottest = No Flow
  - Minimum dT occurs when the needle is coolest = High Flow

- dTM - Maximum dT is recorded and averaged pre-dawn = the zero flow set point.

Original Granier Design

Dynamax Improvements

- Smaller Needles
- Internally mounted heater
- Teflon Coated Probes



TDP - Measurement Principle

- **Calculate Dimensionless Variable K**

$$K=(dTm - dT)/dT$$

- **Calculate Velocity V**

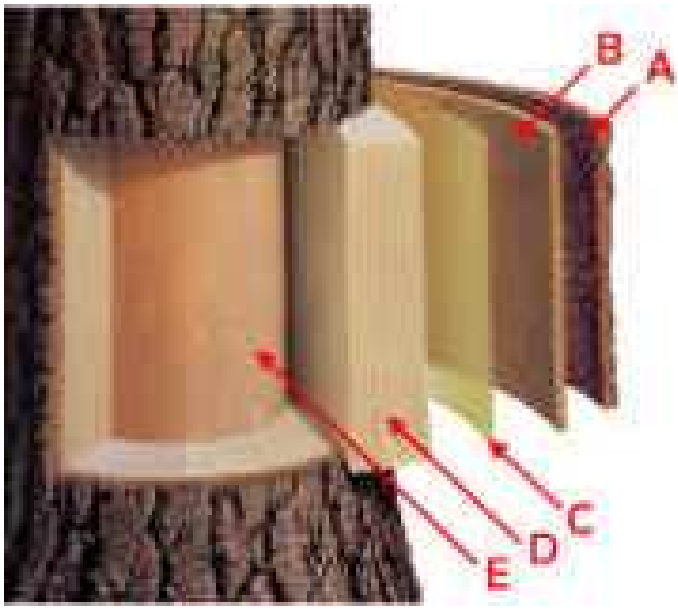
$$V= 0.000119 * K \wedge 1.231 \quad (m/s)$$

- **Calculate Area of Sapwood & multiply to obtain volume flow**

$$Sapflow =A * V$$

Sapwood Area

(A) Outer Bark
(B) Inner Bark
(C) Cambium Layer
(D) Sapwood
(E) Heartwood



- Only the Sapwood conducts water
- Only the sapwood needs to be measured.
- Maritime Pine (*Pinus pinaster*) – Sapwood thickness = 40-80mm

Sapwood Area Calculations

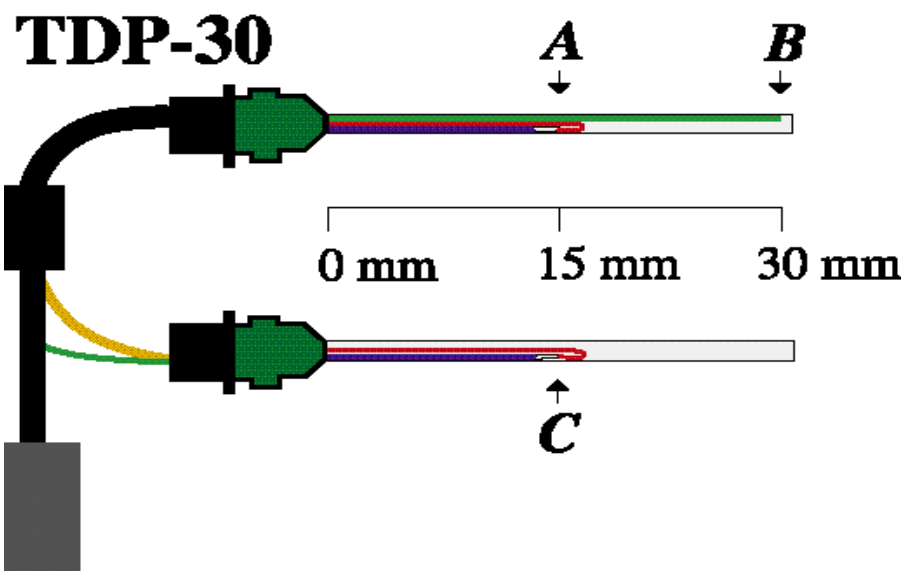
- Sapwood Area must be calculated to Compute Sapflow

- The method used by Grainer
  - Destructive sample & physically measure
    - Stem cores from a sample of trees
    - Measure DBH
    - Calculate the tree circumference S_T
    - Establish Statistical relationship

$$S_A = -0.0039 + 0.59\ S_T$$

TDP-30 Probe Specifications

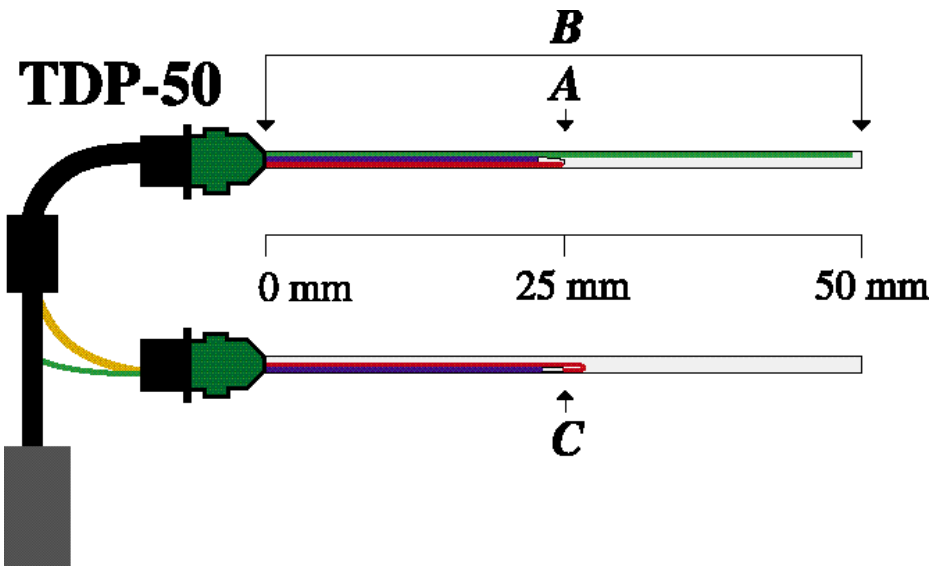
Model	TDP-30
Length	30mm
Diameter	1.2 mm
T-Type T/C's	1 ea
Probe Spacing	40 mm
Power	0.15 to 0.2 w
Cable Standard	10ft/ 5 cond
Heater Resistance	45 Ohms
Operating Volts	3.0 V @~8°C
Signal Out	40 uV/°C



A- Thermocouple #1
B- Heater
C-Reference Thermocouple

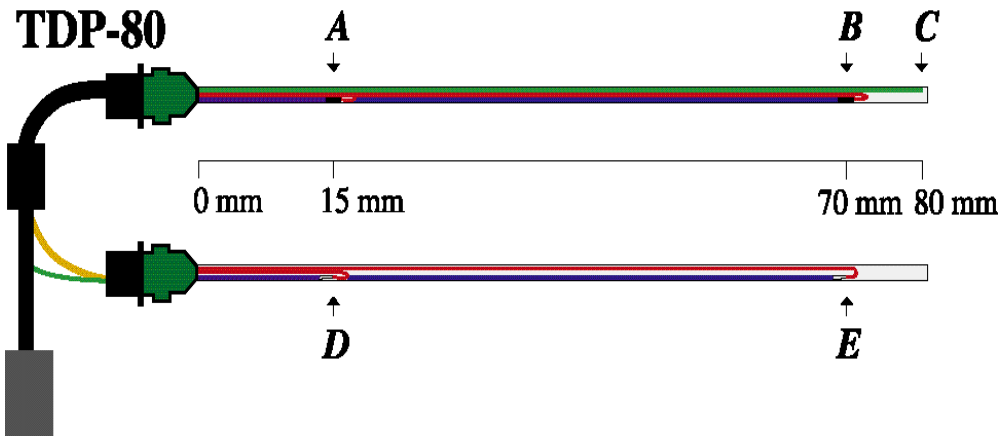
TDP-50 Probe Specifications

Model	TDP-50
Length	50mm
Diameter	1.65 mm
T-Type T/C's	1 ea
Probe Spacing	40 mm
Power	0.32 to 0.38 w
Cable Standard	10ft/ 5 cond
Heater Resistance	77 Ohms
Operating Volts	5.0 V @~8°C
Signal Out	40 uV/°C



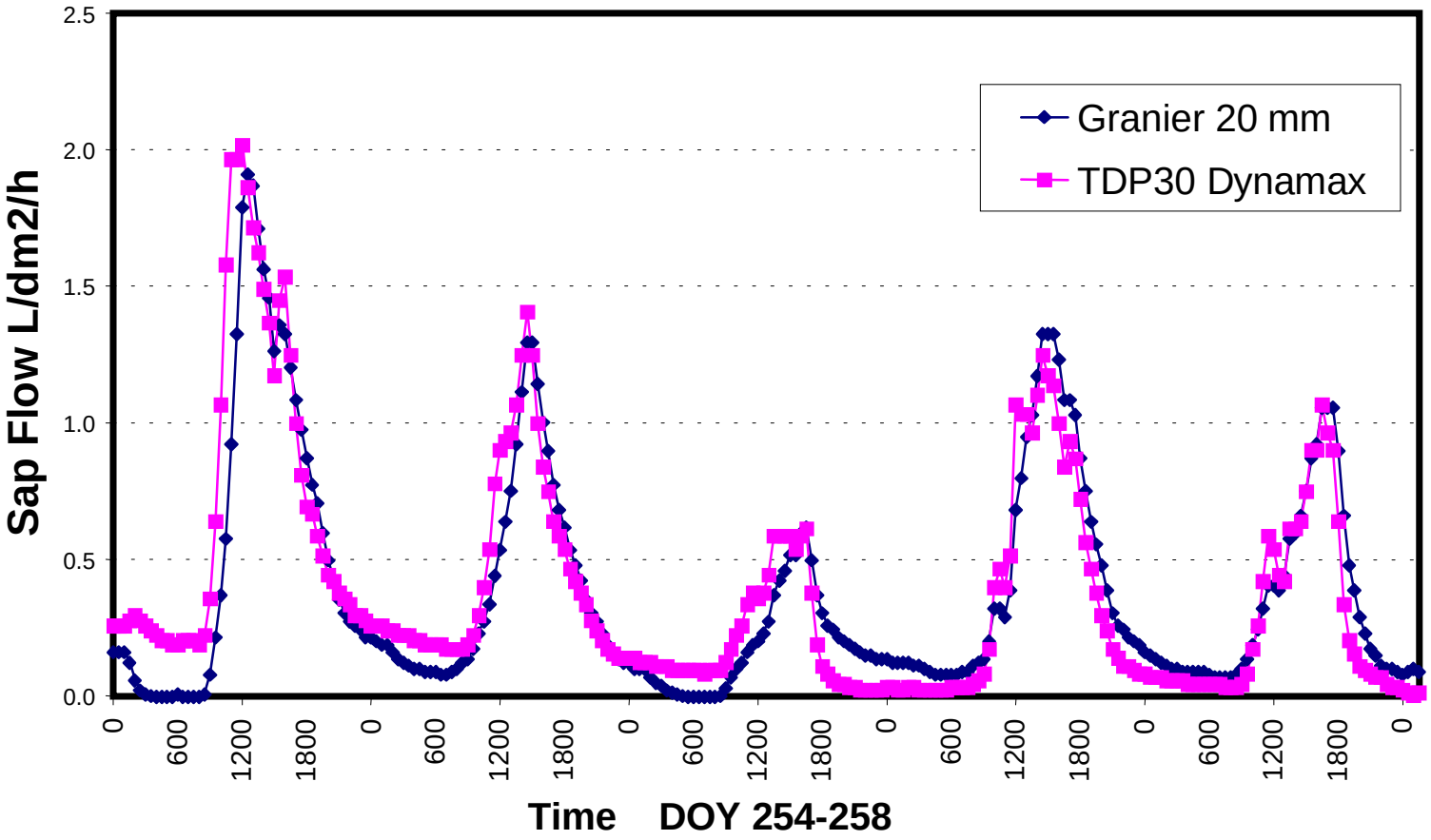
TDP-80 Probe Specifications

Model	TDP-80
Length	80 mm
Diameter	1.65 mm
T-Type T/C's	2 ea
Probe Spacing	40 mm
Power	0.4 to 0.5 w
Cable Standard	10ft/ 7 cond
Heater Resistance	100 Ohms
Operating Volts	7.5 V @~8°C
Signal Out	40 uV/°C



A- Thermocouple #1
B- Thermocouple #2
C- Heater
D- Reference Thermocouple
E- Reference Thermocouple

Sap Flow Calculation - Conifer



Specifications Summary

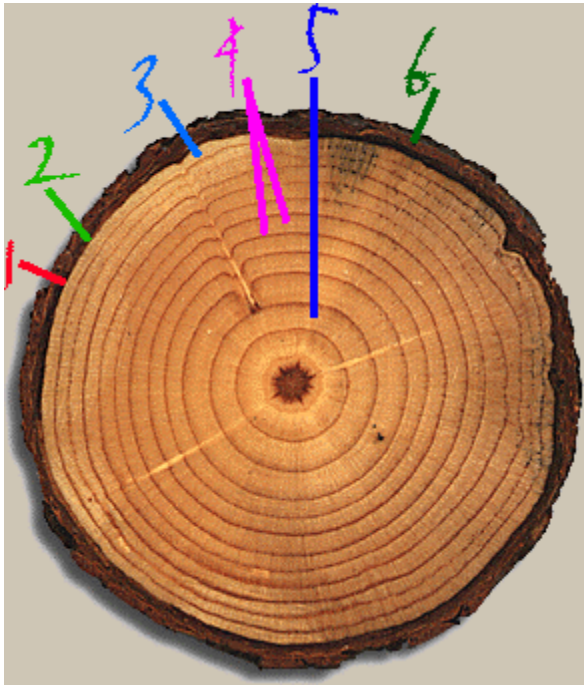
- **Free flexible cable between needles of the sensor specifically designed to improve installation and removal of probes.**

- ***Sensors constructed using solid or epoxy encapsulation methods causes sensor damage during removal. Non-reusable.***

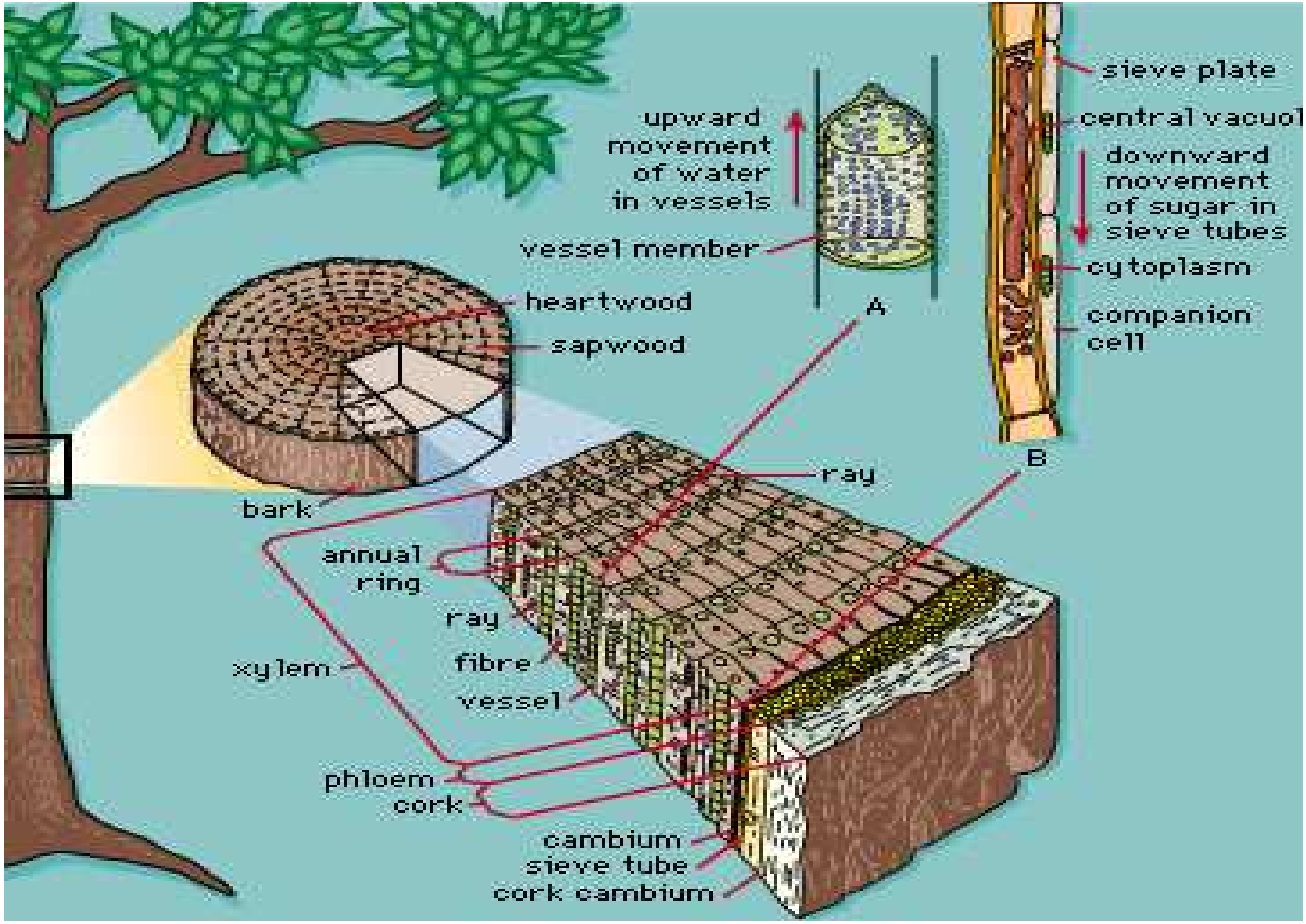
- **Modified Hypodermic syringe minimizes probe diameter**

- ***Grainer concluded the smaller diameter of DYNAMAX design is pivotal to improved responsiveness of DYNAMAX TDP probes over his original prototype.***

How Many Sensors Not How Long!



- Uniform Growth Conditions
- Non-uniform Growth Conditions


upward movement of water in vessels
vessel member
A
sieve plate
central vacuol
downward movement of sugar in sieve tubes
cytoplasm
companion cell
B
heartwood
sapwood
bark
ray
annual ring
ray
fibre
vessel
xylem
phloem
cork
cambium
sieve tube
cork cambium

TDP-30 Species Compatibility

(1) Ring-porous Species

- Large Early wood vessels to small Late wood

(2) Thin xylem

(3) Pinus & Oak Species

- *Pinus radiata* - Monterey Pine
- *Pinus caribaea* - Caribbean Pine
- *Quercus petraea* – Sessile Oak

TDP-50 Species Compatibility

(1) Ring-porous Species
(2) Mature trees with with medium Sapwood

- ***Pinus strobus* - Eastern White Pine**
- ***Juglans nigra* - Black Walnut**
- ***Toona australis* – Red Cedar**
- ***Pseudotsuga menziesii* – Douglas Fir**

TDP-80 Species Compatibility

(1) Diffuse-porous Species

- **No differentiation between early wood & late wood**

(2) Plants with > 30% Sapwood

- ***Populus Deltoides* - Cottonwood**
- ***Acer rubrum* - Red Maple**
- ***Eucalyptus regnans* – Mountain Ash**
- ***Phytolacca dioca* - Ombu Tree**
- ***Mangifera Indica* – Mango Tree**

TDP Sensors

Features

- INRA research (Granier) design
- Verified & supported math
- Two needles epoxy sealed
- Teflon coated probes
- International License
- Multiple probe size
- One differential channel
- Low voltage operation

Benefits

- Continuous Sap Velocity
- Simple data calculation/analysis
- Durable, Reusable Design
- Real-Time Data Acquisition
- Monitor multiple trees
- Monitor large trees
- Universal logger compatibility
- Easy voltage regulation

TDP Probe Installation

Installation Procedure

1. **Prepare the Probe Site:**
   - **Select a height 1-2 meters above the ground**
   - **Remove old rough bark to cambium layer**
2. **Drill Holes:**
   - **Place the Drilling Jig flat on the prepared surface**
   - **Drill a hole with the smallest drill bit**
   - **Enlarge the hole with the larger drill bit (if Required)**
3. **Install Probes:**
   - **Insert the heater in the top hole & the reference in the bottom**
   - **Insert needles slowly and gradually**
   - **Tape cables to the tree for support**

Insulation & Sensor Removal

- **Insulation:**
  - **Install a water proof seal around the needles**
  - **Secure Foam Quarter spheres around probes**
  - **Install thermal insulation using reflective foam Bubble Wrap**
- **Probe Removal:**
  - **Do NOT pull on the base of the needle**
  - **Never use Claw hammers or other long Levers**
  - **Always use the supplied nail removing Pry-bar**
  - **Address the cannula with the pry-bar then, using moderate force withdraw the probes gradually.**

Applications

- Forestry Research
- Commercial Forestry
- Transpiration Research
- Phytoremediation
- Carbon Sequestration

Forestry Research

- Stand Transpiration for projection of Biomass production
- Effects of thinning on tree water use
- Species Water Use requirements for new plantations on marginal land

Commercial Forestry

- Effectiveness of regeneration techniques after harvesting.

- Growth rate modeling for harvesting projections

Transpiration Research

- Whole tree water use
- Transpiration correlation to photosynthesis, light, soil & water
- Spatial variations in xylem sap flux density
- Irrigation efficiencies of mature citrus trees
- Drought tolerance of tree species

Phytoremediation

- Hydraulic containment of contaminated groundwater.
  - Groundwater level reduction
  - Tree stores contaminants
- Calculation of water removal rate
  - Net Stand transpiration rate
  - Determine current removal rate
  - Project future removal rate

Carbon Credits Trading

- Carbon Sequestration
  - New research to determine species carbon accumulation or storage rates and capacities.
  - Used for future environmental trading
  - Offset CO_2 emissions